

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE
in its capacity as elected Office

Date of mailing (day/month/year) 25 May 2001 (25.05.01)	
International application No. PCT/CH00/00483	Applicant's or agent's file reference B-2799-WO
International filing date (day/month/year) 08 September 2000 (08.09.00)	Priority date (day/month/year) 09 September 1999 (09.09.99)
Applicant CROCKETT, Dennis et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:
30 March 2001 (30.03.01)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Charlotte ENGER Telephone No.: (41-22) 338.83.38
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PATENT COOPERATION TREATY

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NOTIFICATION OF THE RECORDING
OF A CHANGE(PCT Rule 92bis.1 and
Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

GANGUILLET, Cyril
ABREMA Agence Brevets et Marques
Ganguillet & Humphrey
16, avenue du Théâtre
P.O. Box 2065
CH-1002 Lausanne
SUISSE

5 NOV. 2001

UGFBU

Date of mailing (day/month/year) 25 October 2001 (25.10.01)	IMPORTANT NOTIFICATION
Applicant's or agent's file reference B-2799-WO	
International application No. PCT/CH00/00483	International filing date (day/month/year) 08 September 2000 (08.09.00)

1. The following indications appeared on record concerning:

☒ the applicant ☐ the inventor ☐ the agent ☐ the common representative

Name and Address

DE LA RUE GIORI S.A.
Rue de la Paix 4
CH-1003 Lausanne
Switzerland

State of Nationality

CH

State of Residence

CH

Telephone No.

Facsimile No.

Teleprinter No.

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☐ the person ☒ the name ☐ the address ☐ the nationality ☐ the residence

Name and Address

KBA-GIORI S.A.
Rue de la Paix 4
CH-1003 Lausanne
Switzerland

State of Nationality

CH

State of Residence

CH

Telephone No.

Facsimile No.

Teleprinter No.

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

☒ the receiving Office ☐ the designated Offices concerned
☐ the International Searching Authority ☒ the elected Offices concerned
☒ the International Preliminary Examining Authority ☐ other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Beatriz LARGO

Telephone No.: (41-22) 338.83.38

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PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference B-2799-WO	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/CH00/00483	International filing date (day/month/year) 08/09/2000	Priority date (day/month/year) 09/09/1999
International Patent Classification (IPC) or national classification and IPC B41J2/175		
Applicant DE LA RUE GIORI S.A. et al.		



1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 5 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

 These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 30/03/2001	Date of completion of this report 23.08.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Schreiber, M Telephone No. +49 89 2399 2831 

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/CH00/00483

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-9 as originally filed

Claims, No.:

1-8 as originally filed

Drawings, sheets:

1/1 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

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**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/CH00/00483

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims 1-8
	No: Claims
Inventive step (IS)	Yes: Claims 1-8
	No: Claims
Industrial applicability (IA)	Yes: Claims 1-8
	No: Claims

- 2. Citations and explanations**
see separate sheet

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Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

The most relevant state of the art is a conventional inkjet printing device with an inkjet printhead for continuous printing according to the preamble of claim 1. The subject-matter of claim 1 differs from such a device in the features of the characterising portion.

The subject-matter of claim 1 is therefore novel (Article 33(2) PCT).

The problem to be solved by the present invention may therefore be regarded as preventing the particles of inks containing a high loading of pigment from settling out of the ink and agglomerating.

The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons: The strongest hint to the distinguishing features can be found in document EP-A-0 736 388 which discloses a drop-on-demand ink jet printing device comprising a mixing arrangement comprising a recirculation loop (11, 105, 103, 105, 11) taking ink from the reservoir (11) and returning it to the reservoir (11), and a stirring system (102) for ink contained in the reservoir (11), and, additionally, a means of heating the ink and ensuring the temperature of the ink is maintained at a predetermined temperature, above the ambient level (see especially page 4, line 28 to page 5, line 10 and Fig. 2). This arrangement is supposed to solve the same problem as in the present invention (see especially page 3, lines 8 to 17).

However, this suggestion does not correspond to the distinguishing features of claim 1, since the recirculation loop shown in the prior art document does not comprise mixing means (part 106 in Fig. 2 is a pump which pumps ink to the head during ejection recovery operation, see page 4, lines 52 to 53).

Furthermore it is doubtful whether a person skilled in the art of continuous ink jet printers would take a teaching concerning a drop-on-demand ink jet printer into account when trying to solve a problem concerning a continuous ink jet printer.

Claims 2 to 7 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

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**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/CH00/00483

Since the process according to claim 8 comprises the step that ink is used for filling the ink reservoir of a printing device according to any one of the claims 1 to 7, the process involves the use of a device according to any one of the claims 1 to 7 and thus claim 8 also meets the requirements of the PCT with respect to novelty and inventive step.

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INTERNATIONAL COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference B-2799-W0	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/CH 00/ 00483	International filing date (day/month/year) 08/09/2000	(Earliest) Priority Date (day/month/year) 09/09/1999
Applicant DE LA RUE GIORI S.A. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the title,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the abstract,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1
☐ Non-fth figures.

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INTERNATIONAL SEARCH REPORT

International Application No.

PCT/CH 00/00483

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 B41J2/175 B41J2/195

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B41J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, IBM-TDB, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 891 654 A (HOISINGTON PAUL A ET AL) 2 January 1990 (1990-01-02) column 5, line 27 -column 6, line 4 figure 5	1,8
A	EP 0 736 388 A (CANON KK) 9 October 1996 (1996-10-09) page 4, line 48 -page 5, line 10 page 7, line 20 - line 34 page 12, line 35 - line 40 figures 2,9	1,2,7
A	EP 0 642 924 A (MATTHEWS INT CORP) 15 March 1995 (1995-03-15) column 7, line 23 -column 9, line 14 figures 2,3	1,2
	-/--	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

5 December 2000

Date of mailing of the international search report

14/12/2000

Name and mailing address of the ISA

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 NL - 2280 HV Rijswijk
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Authorized officer

Papastefanou, E

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INTERNATIONAL SEARCH REPORT

International Application No.

PCT/CH 00/00483

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>PATENT ABSTRACTS OF JAPAN vol. 009, no. 264 (M-423), 22 October 1985 (1985-10-22) & JP 60 110458 A (HITACHI SEISAKUSHO KK), 15 June 1985 (1985-06-15) abstract</p> <p>-----</p>	7

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/CH 00/00483

Pat nt docum nt cited in search r port	Publication date	Patent family m mber(s)	Publication date
US 4891654 A	02-01-1990	US 4835554 A	30-05-1989
		AT 116208 T	15-01-1995
		AT 149919 T	15-03-1997
		BR 8807198 A	17-10-1989
		CA 1306898 A	01-09-1992
		DE 3852635 D	09-02-1995
		DE 3852635 T	27-07-1995
		DE 3855832 D	17-04-1997
		DE 3855832 T	02-10-1997
		EP 0339058 A	02-11-1989
		EP 0597557 A	18-05-1994
		JP 2543972 B	16-10-1996
		JP 2500584 T	01-03-1990
		KR 9210736 B	14-12-1992
		WO 8902577 A	23-03-1989
EP 0736388 A	09-10-1996	JP 8276599 A	22-10-1996
		JP 9104106 A	22-04-1997
		US 5988782 A	23-11-1999
EP 0642924 A	15-03-1995	US 5444472 A	22-08-1995
		AU 686525 B	05-02-1998
		AU 1237097 A	13-03-1997
		AU 686961 B	12-02-1998
		AU 1237197 A	13-03-1997
		AU 677830 B	08-05-1997
		AU 6330894 A	23-03-1995
		CA 2122414 A	08-03-1995
JP 60110458 A	15-06-1985	NONE	

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(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
15 March 2001 (15.03.2001)

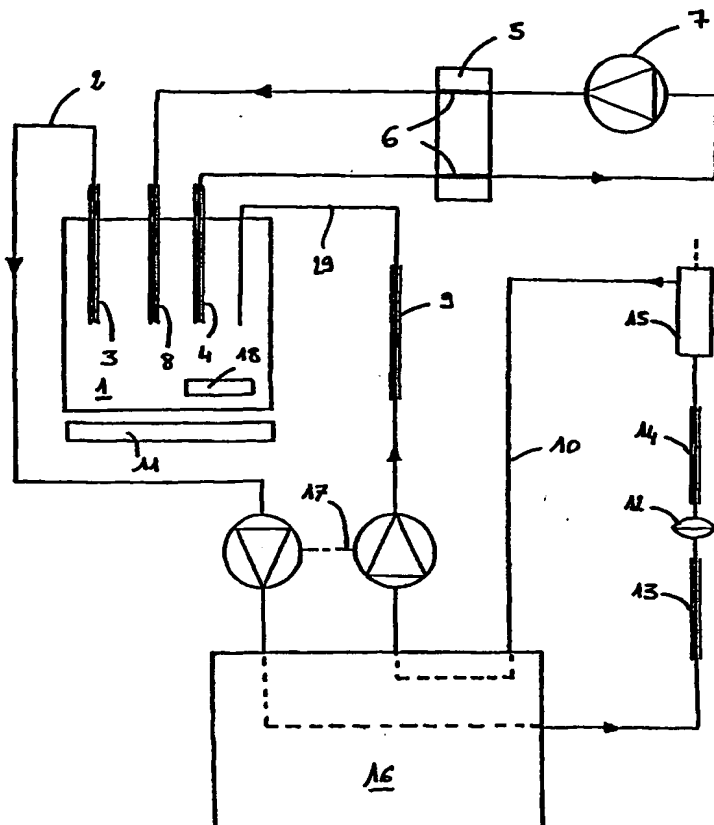
PCT

(10) International Publication Number
WO 01/17783 A1

- (51) International Patent Classification⁷: **B41J 2/175, 2/195**
- (21) International Application Number: **PCT/CH00/00483**
- (22) International Filing Date:
8 September 2000 (08.09.2000)
- (25) Filing Language: **English**
- (26) Publication Language: **English**
- (30) Priority Data:
99810809.6 9 September 1999 (09.09.1999) EP
- (71) Applicant (for all designated States except US): **DE LA RUE GIORI S.A. [CH/CH]; Rue de la Paix 4, CH-1003 Lausanne (CH).**
- (72) Inventors; and
(75) Inventors/Applicants (for US only): **CROCKETT, Dennis [GB/GB]; 72 Westminster Gardens, Eye, Peterborough, PE6 7SP (GB). HUDD, Alan, L. [GB/GB]; Bury Cottage, Nuthampstead, Hertfordshire SG8 8NG (GB). EVANS, Christopher, M. [GB/GB]; 14 Ash Green, Great Chesterford, Essex CB10 1QR (GB).**
- (74) Agents: **GANGUILLET, Cyril et al.; ABREMA Agence Brevets et Marques, Ganguillet & Humphrey, 16, avenue du Théâtre, P.O. Box 2065, CH-1002 Lausanne (CH).**
- (81) Designated States (national): **AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.**

[Continued on next page]

(54) Title: **INKJET PRINTING DEVICE FOR INKS CONTAINING A HIGH LOADING OF PIGMENT AND INKJET PRINTING PROCESS UTILIZING SAID DEVICE**



(57) Abstract: A continuous inkjet printer is described, which comprises a combination of dispersion agitation means, heated ink supply and print-head and tailored, heated, filtration regime. The use of this combination allows the printing of inks containing a non-magnetic pigment that exhibits "soft settling" upon standing.

WO 01/17783 A1



(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

— With international search report.

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Inkjet printing device for inks containing a high loading of pigment and Inkjet printing process utilizing said device

This invention relates to an inkjet printing device for inks containing a high loading of pigment, comprising an inkjet printhead for continuous printing, an ink reservoir, and a feeding circuit for feeding said printhead with ink from the reservoir and returning gutter ink from the printhead to the reservoir. The invention also relates to an inkjet printing process for inks having a high content in high density pigment.

There is an increasing interest in the printing of pigmented inks. However it is well known that when inks contain high density pigments the high density make them difficult to incorporate into inkjet inks. The Brownian motion of the particles in dilute solution is not sufficient to overcome gravitational forces and the particles tend to settle out of the ink and agglomerate. The continuous inkjet printing industry has battled against this problem for over ten years. It is still widely believed within this industry that in order for a pigmented ink to be successfully applied using inkjet the dispersion must be stable. This requirement places very stringent demands on the ink chemistry, more particularly when inks containing a high loading of pigment or having formulations with room temperature viscosities in excess of 12 cPs or inks that contain security features such as fluorescent pigments have to be applied with continuous inkjet printing technology.

It is an object of the present invention to propose a solution to this problem.

Experiments made by the Applicant with this end in view, have shown that through the utilisation of the device according to

the present invention an ink which has only a certain minimum degree of dispersion stability and which exhibits a phenomenon termed "soft settling" can be successfully run and printed in a single nozzle continuous inkjet printer

A dispersion which exhibits soft settling is one in which the pigment settles out of dispersion on standing, but is readily redispersed by the application of mild agitation or shaking. A hard settling dispersion is one that cannot be readily redispersed after standing for a period of time.

The present invention therefore relates to an inkjet printing device for inks containing a high loading of pigment, comprising an inkjet printhead for continuous printing, an ink reservoir, and a feeding circuit for feeding said printhead with ink from the reservoir and returning gutter ink from the printhead to the reservoir, wherein the device further comprises on the one hand a two stages mixing arrangement comprising a recirculation loop with mixing means, taking ink from the reservoir and returning it to the reservoir, and a stirring system for ink contained in the reservoir, and, additionally, a means of heating the ink and ensuring the temperature of the ink is maintained at a predetermined temperature, above the ambient level.

According to a preferred embodiment, at least five static mixers are incorporated at strategic points within the system and the printhead feeding circuit comprises a filter placed between two static mixers, upstream of the printhead, and filter heating means arranged in such a manner that the ink temperature in the filter is higher than elsewhere in the printhead supply line. Further, a recirculation loop comprises a recirculation pump located between two static mixers

According to a second aspect, the invention relates to a process for inkjet printing with inks formed of a dispersion of particles in a liquid.

An embodiment of the device as well as an example of the process will be described hereinafter with reference to the drawing.

FIG. 1 is a schematic view showing a printing device incorporating the features of the invention.

Referring to the drawing, reference 1 designates an ink reservoir. The shape of this reservoir should preferably be such that efficient stirring of the ink is facilitated. It should not contain any "dead" volume. A cylindrical shape with a rounded bottom edge has been shown to be satisfactory. Also a hemispherical shape of the reservoir would be satisfactory. One experimental implementation of this concept has utilised a 500ml circular jar with a screw-on lid as a reservoir.

Ink is picked up in the reservoir through a feed line 2 and passes through a first static mixer 3. A static mixer is a well known apparatus which consists of a series of left and right hand helical elements located within a straight tube part. Several companies manufacture mixers of this type. Those manufactured by TAH Industries Inc., of New Jersey USA as well as those manufactured by Statiflo International Ltd., of Cheshire UK have been found to be useful.

Ink pick up line 2 feeds a pump assembly 17 and an ink supply and management system 16.

References 4 to 8 designate an ink recirculation loop which constitutes an important part of the schema. Ink is taken out of the tank 1 through a second static mixer 4, is passed

through a stainless steel tube 6, then through a recirculation pump 7 which is preferably a peristaltic pump, then through a further stainless steel tube 6 and returned to the reservoir 1 through a third static mixer 8. Both stainless steel tubes 6 are parallelly sunk within the same aluminium block 5 provided with heating means, allowing the stainless steel tubes 6 to be maintained at a constant temperature. The flow rate through the recirculation loop is maintained at a rate several times faster than the flow of ink through the printing side of the system.

Tank 1 finally comprises the return line 29 coming out of the ink management system 16 and going through a fourth static mixer 9. Said fourth mixer 9 is however optional. Acceptable results have been obtained without the same.

Tank 1 is positioned on top of a magnetic stirrer 11 and contains a magnetic stirrer bead 18. Thus two independent agitation means are provided: the recirculation loop 4-8 and the additional stirrer 11 and 18. The latter could also be a rotating mechanic stirrer.

The ink management block 16 includes the pump assembly 17, here symbolised through a pair of separate suction and driving pumps. However this representation is provided as an example only. The ink management block further includes a number of connection and valve and control means which are not represented in detail and which ensure control of the pressure and the composition of the ink: ink supply, solvent supply, measurement of viscosity, flow rate control, etc., as well as feeding of wash liquid. This system may include ink make up reservoir, solvent reservoir, etc.

A further line feeds ink from the management block 16 to the printhead 15. It comprises fifth and sixth static mixers 13

and 14 respectively and a filter 12 provided between the static mixers 13 and 14. Filter 12 is provided with heating means. At the outlet of mixer 14 the ink enters printhead 15 which is a single nozzle heated printhead. The gutter of printhead 15 is returned to ink management block 16 through line 10 and from there to the ink reservoir 1 through static mixer 9.

The operating conditions of the device described will now be discussed.

As has been stated above, the object of the device is to permit a continuous inkjet printer to function with inks containing difficult to disperse pigments. Increasing the viscosity of an ink increases the dispersion stability by decreasing the ease with which the pigment can settle out. However the continuous inkjet printers presently known are designed to work with inks of viscosities between 2.5 and 10 cPs, preferably between 2.8 and 4 cPs. It has been shown, however, that with the device described herein, ink formulations with room temperature viscosities in excess of 12 cPs can be printed. This makes possible the use of inks with higher pigment loadings or increased polymer stabilisation.

The heated ink delivery system as described above is an important feature. Thus for instance tests have shown that despite setting the printhead temperature at 50 degrees C a temperature of approx. 35 degrees C was the maximum that could be obtained. When the temperature of the ink supply was raised to 45-50 degrees C e.g. through passage of the ink in the loop 4-8, the desired head temperature could be achieved. Therefore both the heated printhead and heated ink delivery system are necessary.

Certain aqueous base inks give rise to condensation on the charge electrode when used with a printer as described herein, especially when operating with an elevated printhead temperature. The formation of this condensation, which eventually causes the printer to cease working, can be prevented by the application of a slight positive pressure of air to the charge electrode or, preferably, through the application of low level heat.

Two different mixing technologies comprising a) mixing of the bulk ink in the tank through magnetic or other rotating stirring means and b) constant recirculation in a loop with static mixers, have been found to be necessary and to allow soft settling dispersions to be applied. Soft settling dispersions can be made with difficult to disperse pigments or additional materials intended to add further functionality to the ink.

The use of the described device not only maintains a homogeneous dispersion when the printer is working, but also allows an efficient redispersion of pigment after the printer has been shut down for a period of time (e.g. overnight). When restarting the machine it is only necessary to start the mixing systems in sequence, and then run for a short period of time prior to commencing printing. This redispersion process is aided by utilising a reservoir shape that does not contain any "dead" volume, as described above.

The association, as near as possible from one another, of a heated filter with static mixers located immediately before and after the filter, and of a heated printhead is a key component of the invention.

A heated filtration regime achieves excellent flow characteristics. The purity of flow through a filter is

improved and less pressure is required to achieve an acceptable flow rate. Using high pressure with high viscosity would be detrimental to the maintenance of the filter. In addition, by heating the ink the viscosity is reduced which improves the filtration properties of the ink.

Reducing the viscosity increases the rate of pigment settlement, which is undesirable. Therefore to heat the ink to a higher temperature in the region of the filter than elsewhere in the ink supply line improves the filtration properties whilst minimising the settling rate elsewhere in the printer.

Finally a static mixer to the inlet of the filter prevents blockage or loading caused by heterogeneous flow of ink. A static mixer on the exit of the filter ensures that the ink leaving the filter is homogeneous. This is especially important just prior to the nozzle as ink homogeneity is a key requirement for reliable drop formation and jetting.

Tests.

Tests made with a printing device as described have shown the following results:

1. Ink with a viscosity of 5.6 cPs was printed under ambient conditions. The ink recirculation system was unheated. The recorded temperature of both the printhead and the ink was 27 degrees C. The pump pressure and the modulation voltage were set at 2900 mbar and 400 V respectively. The print quality was good.

2. Ink with a viscosity of 12.5 cPs was then printed with the inkjet printer operating in the same conditions as above.

(Printhead and ink temperature at 27 degrees C). Printing was not possible.

3. The same ink as for test No. 2 was then printed with raising the ink temperature to 44 degrees C and running the printhead at 35 degrees C. The pump pressure and modulation voltage were set at 2815 mbar and 600 V respectively. A satisfactory print could be obtained. The charge electrode was maintained at a temperature of approximately 60 degrees C during this experiment by heating with a 10 W radiant heat source to prevent the formation of condensation as described above.

This ink was observed to settle out within 1 hour of standing when the magnetic stirrer and recirculation loop were turned off, the ink temperature being maintained at 25 degrees C

4. Ink with viscosity of approx. 13 cPs was placed in the ink reservoir and then mixed using the magnetic stirrer and the recirculation loop 4-8 as described. Samples of ink were removed from the reservoir at intervals and their viscosity measured:

Time (min)	0	30	60	90	120
Viscosity (cPs)	13.3	13.9	13.7	13.6	13.4

Thus a stable dispersion is maintained when both mixing techniques are used. The viscosity was measured at 30 rpm.

5. After mixing for a period of 2 hours, the recirculation loop and the magnetic stirrer were turned off and the ink left to stand with no agitation.

Within approximately 10 min of the cessation of stirring one could observe visually a significant outsettling.

Time after cessation of stirring	30 min	15 hours
Measured viscosity (cPs)	11.3	11.4

Thus when no additional agitation is used, the dispersion readily settles out.

Maintenance process.

In addition to the different operating steps described above, the following maintenance process can be employed to further improve the reliability of this system.

The system should have a separate flush system containing clean filtered wash fluid. This will be in addition to the replenishment fluid.

Upon shutdown, ink is drained from the head and pipes, and returned to the internal ink container. Flush solution is then pumped throughout the system to rigorously remove the ink. Throughout the sleep mode the printer is left sealed, containing clean filtered wash fluid.

During the start up sequence, the ink within the ink container will be vigorously stirred, the wash fluid is pumped from the system and ink is introduced with a pulsed pressure regime.

Maintenance during operation will involve periodic flushing of ink throughout the system to ensure no settlement occurs. This will be achieved by briefly pulsing the system with ink between print jobs.

Air management will be important, e.g. by operating under negative pressure or degasing.

Claims

1. Inkjet printing device for inks containing a high loading of pigment, comprising an inkjet printhead (15) for continuous printing, an ink reservoir (1), and a feeding circuit (2, 10) for feeding said printhead with ink from the reservoir and returning gutter ink from the printhead to the reservoir, characterized in that the device further comprises on the one hand a two stages mixing arrangement comprising a recirculation loop (5, 6, 7) with mixing means (4, 8), taking ink from the reservoir and returning it to the reservoir, and a stirring system (11, 18) for ink contained in the reservoir, and, additionally, a means of heating the ink and ensuring the temperature of the ink is maintained at a predetermined temperature, above the ambient level.

2. Device according to claim 1, characterized in that at least five static mixers (3, 4, 8, 13, 14) are incorporated at strategic points within the system.

3. Device according to claim 2, characterized in that the printhead feeding circuit comprises a filter (12) placed between two static mixers (13, 14), upstream of the printhead, and filter heating means arranged in such a manner that the ink temperature in the filter is higher than elsewhere in the printhead supply line.

4. Device according to claim 2, characterized in that the recirculation loop comprises a recirculation pump (7) located between two static mixers (4, 8).

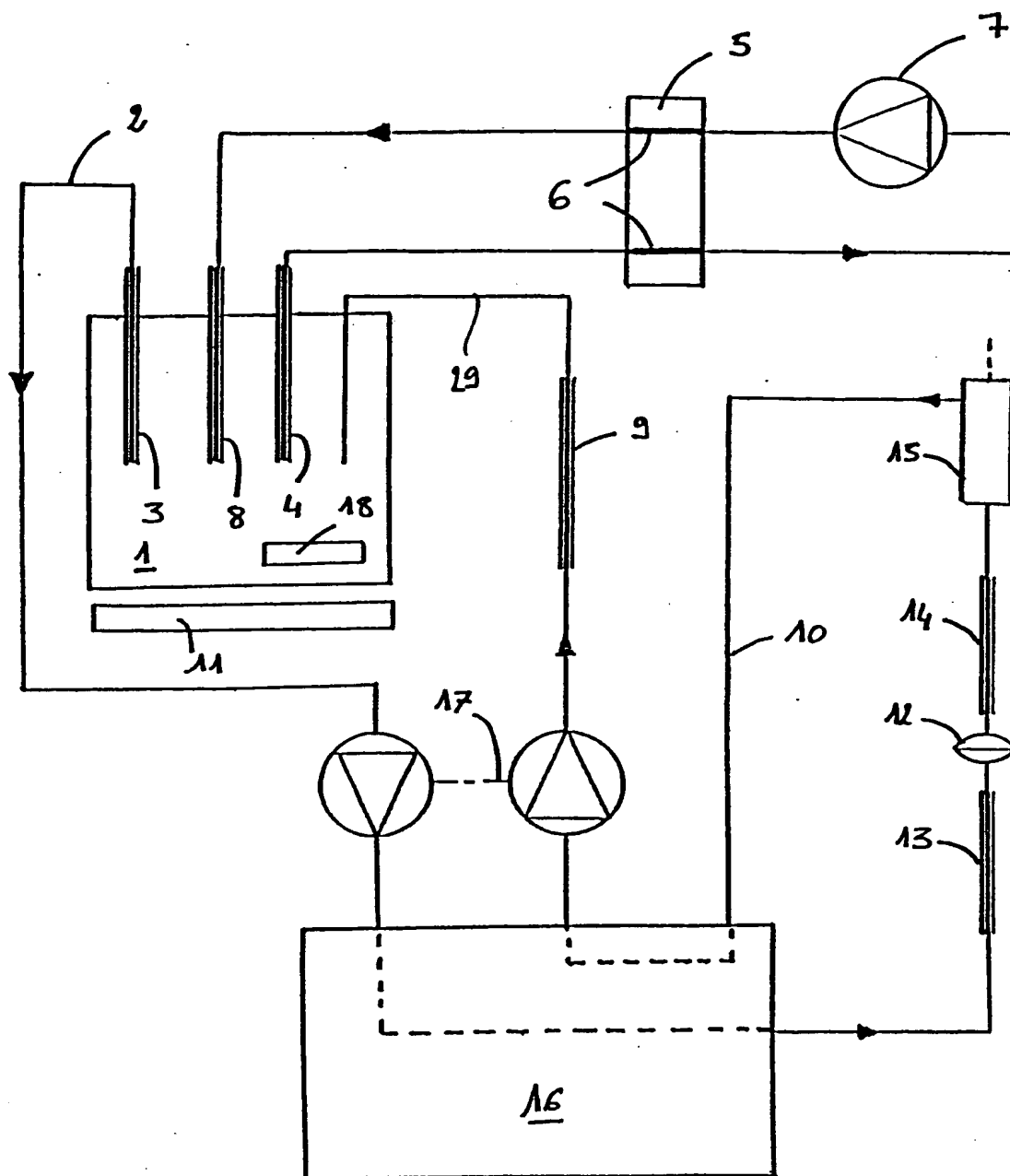
5. Device according to claim 4, characterized in that the recirculation pump is a peristaltic pump.

6. Device according to claim 4, characterized in that the recirculation pump is associated with inlet and outlet tube segments (6) sunk in a heated block for maintaining the said main ink temperature level of the device

7. Device according to claim 2, characterized in that the said stirring means for ink in the reservoir consist of a magnetic stirring arrangement or of a mechanical rotating stirrer.

8. Inkjet printing process for inks having a high content in high density pigment, characterized in that an ink which exhibits the phenomenon of "soft settling" is prepared, and this ink is used for filling the ink reservoir of a printing device according to any one of the claims 1 to 7.

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**FIG.1**

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INTERNATIONAL SEARCH REPORT

In .ational Application No

PCT/CH 00/00483

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B41J2/175 B41J2/195

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B41J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, IBM-TDB, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 4 891 654 A (HOISINGTON PAUL A ET AL) 2 January 1990 (1990-01-02) column 5, line 27 -column 6, line 4 figure 5	1,8
A	EP 0 736 388 A (CANON KK) 9 October 1996 (1996-10-09) page 4, line 48 -page 5, line 10 page 7, line 20 - line 34 page 12, line 35 - line 40 figures 2,9	1,2,7
A	EP 0 642 924 A (MATTHEWS INT CORP) 15 March 1995 (1995-03-15) column 7, line 23 -column 9, line 14 figures 2,3	1,2
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

International Application No

PCT/CH 00/00483

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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